

Production of the ragworm *Nereis diversicolor* (O. F. Müller, 1776), fed with a diet for gilthead seabream *Sparus auratus* L., 1758: survival, growth, feed utilization and oogenesis

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ABSTRACT

A 65-day experiment was conducted to determine survival, growth, feed utilization and oogenesis of *Nereis diversicolor* (O. F. Müller, 1776), fed with a commercial dry diet developed for gilt-head seabream *Sparus auratus* L., 1758. Worms were reared in three replicate tanks with 50 worms per tank ($255 \text{ indiv} \cdot \text{m}^{-2}$). Tetramin®, a commonly used diet for ornamental fish and polychaete laboratory experiments, was used as a control.

Survival was high ($> 95.3\%$) for both treatments, and not significantly affected by diet. Specific growth rates and feed efficiency ratios did not differ significantly between worms fed with either diets, nor were there significant differences in the proportion of individuals in the oocyte size classes.

Keywords: *Nereis diversicolor*, *Sparus auratus*, polyculture, growth, oogenesis.

RESUMEN

Producción del poliqueto *Nereis diversicolor* (O. F. Müller, 1776) alimentado con dieta de dorada *Sparus auratus* L., 1758: supervivencia, crecimiento, utilización del alimento y oogénesis

La supervivencia, el crecimiento, la utilización del alimento y la oogénesis de *Nereis diversicolor* (O. F. Müller, 1776) alimentado con pienso de dorada *Sparus auratus* L., 1758 fueron estudiados durante 65 días. Los poliquetos se cultivaron en tres tanques replicados con 50 individuos en cada uno ($255 \text{ indiv} \cdot \text{m}^{-2}$). Como control se utilizó Tetramin®, una dieta común para peces ornamentales y en experimentos de laboratorio con poliquetos.

La supervivencia fue alta ($> 95,3\%$) en ambos tratamientos y no se vio afectada significativamente por la dieta. El aumento de peso y los cocientes de eficiencia alimentaria no variaron significativamente entre los poliquetos alimentados con ambas dietas. Entre los grupos experimentales no hubo diferencia significativa en la proporción de individuos por clases de tamaño de los oocitos.

Palabras clave: *Nereis diversicolor*, *Sparus auratus*, policultivo, crecimiento, oogénesis.

INTRODUCTION

The culture of the gilthead sea bream *Sparus auratus* L. 1758 is a growing industry in Portugal and Spain. Farming is mostly carried out in earthen ponds in semi-extensive and intensive systems based on the consumption of specific commercial dry feeds. As in most monoculture systems, undesirable wastes are produced, with uneaten feed and the faeces produced by the fishes constituting a considerable part of the organic fraction of these effluents.

The integration of organisms into different positions of the food chain in polyculture systems can be used to reduce the environmental impact of aquaculture effluents (Brzeski and Newkirk, 1997). The polychaete *Nereis diversicolor* (O. F. Müller, 1776), seems to be a good candidate for this integration, since: 1) this species can obtain nourishment as a carnivore, herbivore, suspensivore, or detritivore (Bradshaw *et al.*, 1990; Nielsen *et al.*, 1995; Riisgård, 1991); 2) it has a high tolerance to variations in environmental conditions such as temperature, salinity, and oxygen content (Kristensen, 1983; Ozoh and Jones, 1990); 3) it plays a major role in organic matter decomposition and nutrient cycling processes in sediments (Banta *et al.*, 1999; Heilskov and Holmer, 2001); and 4) it is commonly found inside or in the immediate vicinity of fish farms, in higher densities near automatic feeders (Pocklington, Scott and Schafer, 1994; Pousão-Ferreira, Machado and Cancela da Fonseca, 1995). The reproductive behaviour of *N. diversicolor* can also be seen as an advantage, since this species spawns in the atokous form (Dales, 1950; Bartels-Hardege and Zeeck, 1990), making it possible to establish a population in restricted areas. Furthermore, this species, like other polychaetes belonging to the Nereidae family, has a high economic value due to its use as bait for sport and professional fishing; moreover, a new market is being discovered in the aquaculture industry, that of food for finfish and crustacean broodstocks (Dinis, 1986; Gambi *et al.*, 1994; Olive, 1999).

The present work is part of a broader study which aims to elucidate the feasibility of an integrated polyculture system featuring *S. auratus* and *N. diversicolor*. The objective of this study was to evaluate the survival, growth, feed utilization and oogenesis of *N. diversicolor* fed with a commercial *S. auratus* diet, in order to test whether this species can use the uneaten feed of *S. auratus* as a food source.

MATERIALS AND METHODS

Hatchery-reared juvenile *N. diversicolor* from the Tavira Shellfish Hatchery Station of the Portuguese Institute for Fisheries and Sea Research (Ipimar) were randomly selected from culture tanks and sequentially stocked into the experimental units. A subsample of 40 individuals was randomly collected and used for measuring initial weight (7.8 ± 0.7 mg mean wet weight \pm SE). Initial and final weights of worms were determined after 24 h of starvation to empty the gut and 2 min. drainage on absorbent paper. The animals were reared for a period of 65 days, and each treatment was run in three replicate tanks with 50 worms per tank ($255 \text{ indiv. m}^{-2}$).

The rearing system consisted of a series of tanks (0.196 m^2) with constant aeration. Medium sand ($250\text{-}500 \mu\text{m}$) was dried in an oven at 90°C for 24 h to kill any organisms present. The sand was placed in the tanks to a depth of 4 cm. Worms were reared under natural photoperiod (January to March in 2001; $37^\circ 07' \text{ N}$, $7^\circ 38' \text{ W}$) at ambient temperature, with a mean \pm SD (range) maximum temperature of $16.6 \pm 2.2^\circ\text{C}$ (22-13) and minimum temperature of $13.8 \pm 1.9^\circ\text{C}$ (11-18). Salinity was maintained at 36 in both treatments, representing the main conditions of the *S. auratus* production areas in the south of Portugal and Spain.

Worms were fed with two different types of feed every other day to apparent satiation, which resulted in very similar amounts of feed distributed for both treatments. The amount of food given was recorded. The diets were a low-cost *S. auratus* dry feed (56 % crude protein) and Tetramin® dry feed, developed for ornamental fish (46 % crude protein). The latter last diet was used as a control, since it is commonly employed successfully in polychaete laboratory experiments (Garwood and Olive, 1981; Fidalgo e Costa, Narciso and Cancela da Fonseca, 2000).

At the end of the experiment, all animals from each tank were counted, and the individual wet weight determined. The specific growth rate (SGR):

$$\% \text{ d}^{-1} = 100 [\ln (\text{final wet weight}) - \ln (\text{initial wet weight})] / \text{duration},$$

and the feed efficiency ratio (FER):

$$(\text{final wet weight} - \text{initial wet weight}) / \text{dry food consumed}$$

were calculated.

A sample of 10 individuals per tank was randomly removed for sexual differentiation. The sexual

maturity of the females present in each sample was quantified by taking samples of the coelomic fluid and measuring 30 oocytes per female.

Data from the experiment, which had a completely randomised design with three replicates per treatment, was analysed with Student's t-test to examine differences in survival, specific growth rate, and food efficiency ratio between treatments (Zar, 1984).

Treatments were replicated, but for analysis purposes, data concerning oocyte size were pooled. Individual females were assigned to 30 µm oocyte frequency categories according to the mean of the oocyte diameter, and were then compared statistically using a G-test procedure following the methodology used by Olive, Simon and Djunaedi (1998). Statistical significance was examined at $P < 0.05$.

RESULTS

Survival was high for both treatments and not significantly ($P > 0.05$) affected by the diets. Specific growth rate and food conversion ratio did not differ significantly ($P > 0.05$) between worms fed with the two diets (table I).

Table I. Survival, specific growth rate and feed efficiency ratio of *N. diversicolor* fed with *S. auratus* dry feed (SBDF) and ornamental fish dry feed (OFDF) for 65 days. Data represent mean of three tanks (SE)

Diets	Survival (%)	Specific growth rate (% d ⁻¹)	Feed efficiency ratio
OFDF	99.3 (0.7)	7.78 (0.03)	1.62 (0.04)
SBDF	95.3 (1.3)	7.88 (0.17)	1.89 (0.14)

A high variability was observed between worms within replicate tanks in both feeding regimes (figure 1).

A G-test analysis found no significant differences in the proportion of individuals in the oocyte size classes between treatments (figure 2).

DISCUSSION

Due to the differences in experimental conditions, it is difficult to compare the results obtained in this study with those obtained in other studies carried out with *N. diversicolor*. One of main difficulties was the worm size, since most studies were carried out with larger individuals (Nielsen *et al.*, 1995; Fidalgo e Costa, Narciso and Cancela da Fonseca, 2000). In addition, these experiments used individual or small groups of worms, making direct comparisons even more difficult. Nevertheless, the SGR obtained in the present study were higher than SGR of 6.8 % d⁻¹ reported by Fidalgo e Costa, Narciso and Cancela da Fonseca (2000) for one-month-old *N. diversicolor* fed Tetramin® with a density of 390 indiv. m⁻². These differences can be explained by the lower density used in the present study (255 indiv. m⁻²), which is in agreement with results obtained by Bridges *et al.* (1996) in *Nereis arenaceodentata*: they reported a decrease in growth when density was high. On the other hand, a higher variability between replicate tanks was observed in the SGR and FER of worms reared on *S. auratus* dry feed (SBDF), in comparison with the control diet. This variability can be explained by the different homogeneity of the two feed pellets, since the Tetramin®

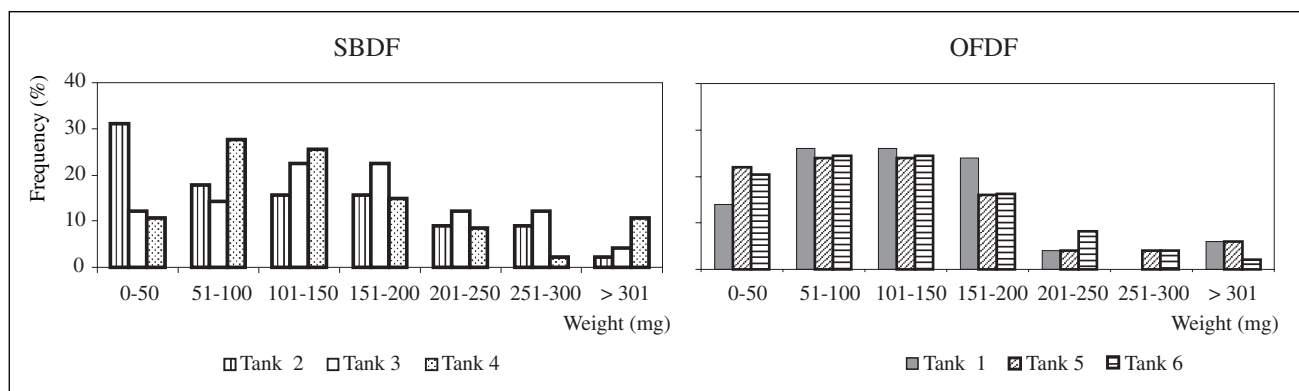


Figure 1. Frequency distribution of *N. diversicolor* from replicate tanks, fed with *S. auratus* dry feed (SBDF) and ornamental fish dry feed (OFDF) for 65 days

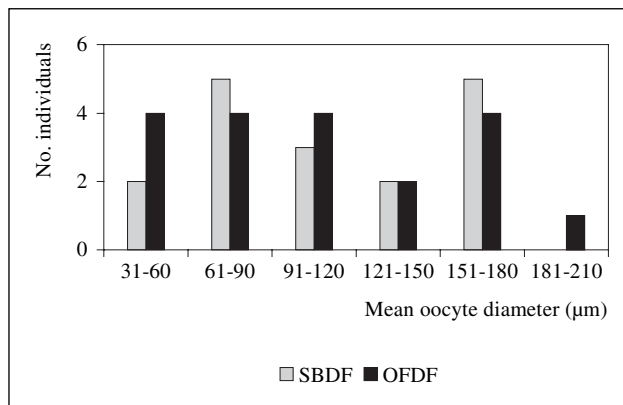


Figure 2. Distribution frequency for individual females *N. diversicolor* fed with gilthead *S. auratus* dry feed (SBDF) and with ornamental fish dry food (OFDF) classified into 30 µm groups by mean oocyte diameter

pellets were much more heterogeneous and numerous than the SBDF pellets, allowing worms of different sizes to ingest pellets of adequate size, thus reducing competition for food. Given that no differences were found in SGR and FER between worms fed with the two diets, the results of the present study suggested that the tested SBDF can support good growth rates.

A high variability was observed in the present study between worms within tanks fed with both diets. These results are in agreement with other observations by Fidalgo e Costa (1999) for *N. diversicolor*. In addition, unpublished data collected by the present authors when juvenile *N. diversicolor* were individually reared under similar conditions (23.6 mg individual wet weight; $n = 22$) during 27 days showed a high variability in specific growth rates (4.0-6.9 % d^{-1} , with coefficient of variation of 14.4 %). These findings suggest that the heterogeneous growth observed between worms within tanks in the present study may have been caused by genetic differences, promoting size-dependent dominance and subsequent feeding hierarchies.

The advanced stage of maturation of some females observed in the present study, and the fact that larvae were observed in both treatments approximately one month after the end of the experiment, supports the idea that precocious maturation in some polychaetes can be achieved by optimization of the feeding rate (Grémare, Marsh and Tenore, 1988; Fidalgo e Costa, unpublished).

The results of the present study indicate that the polychaete *N. diversicolor* is able to flourish and re-

produce using the tested SBDF as a food source, confirming the species's good prospects for polyculture with *S. auratus* (Pousão-Ferreira, Machado and Cancela da Fonseca, 1995).

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